On the Vertebrata of the Dakota Epoch of Colorado.

By E. D. Cope.

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Not long since I was informed by the Superintendent of Public Schools of Fremont County, Colorado, Mr. O. W. Lucas, that he had discovered the bones of an enormous saurian at an outcrop of the rocks of the Dakota group not far from Canyon City. I encouraged him to proceed with the exploration, and asked him to send some specimens which would explain the character of his discovery. One of the first objects sent, is a fragmentary lower jaw of a carnivorous dinosaurian, which he found on the surface of the ground. This fossil was found to belong to a species heretofore unknown, which I referred to the genus *Laelaps*, under the name of *Laelaps trihedrodon.** The second sending included a number of vertebræ, which apparently represent a much more gigantic animal, and I believe the largest or most bulky animal capable of progression on land of which we have any knowledge. This reptile I described in my paleontological bulletin No. 26, under the name of *Camarasaurus supremus*. Subsequent sendings included many of the more important bones of the skeleton, which render it comparatively easy to determine the general character of this monster. Later collections received from Mr. Lucas include the teeth of two large species of a new genus which has been characterized under the name of *Caulodon;* and the vertebræ of three genera new to science, which I have named *Tichosteus*, and *Symphyrophus*. He also procured remains of two additional forms of gigantic size, fit rivals of the *Camarasaurus*, which I referred to the new genus *Amphicœlias*. A species of tortoise was associated with these saurians, and appears to have been abundant. It is the oldest species of the order yet obtained from American formations, and is not very different from existing forms.

The above named genera are the only ones from the Dakota horizon of this continent which have been defined, up to the present time.

The species of *Camarasaurus* and *Amphicœlias*, which attained to the most gigantic proportions, are remarkable for the light construction of the vertebræ anterior to the tail. In both genera the centra of the dorsal vertebræ are hollow, including two large chambers which are separated by a longitudinal median wall, and which communicate with the cavity of the body by a foramen on each side. They are also remarkable for the enormous elevation of the superior arches, and diapophyses, the result of which is to give the ribs an unusually elevated basis, and the cavity of the body much space above the vertebral axis on each side. On the other hand the bones of the tail and limbs are solid or nearly so, in great contrast with some of the *Dinosauria* of later geological periods. Another peculiarity of the genus *Camarasaurus* at least, is the probable great length of the an-

* Bullet. U. S. Geol. Surv. Terrs. III, 1877, p. 805.

terior limbs. The scapula is enormous as compared with the pelvic bones. The sacrum is also small and short, showing that the weight was not borne on the hinder limbs. The great length of the humerus in the probably allied genus *Dystrophæus*, from the Trias of Utah, adds to the probability that the same bones were large in *Camarasaurus*. This character, taken in connection with the remarkably long neck possessed by that genus, suggests a resemblance in form and habits between those huge reptiles and the giraffe. While some of the later *Dinosauria* elevated themselves on their hind limbs to reach the tree-tops on which they fed, the general form of the body in some of these earlier types enabled them to reach their food without the anterior limbs leaving the earth.

Another remarkable peculiarity which these genera share with *Dystrophæus* and *Cetiosaurus* is the irregular and pitted character of the articular extremities of some of the bones. This indicates a cartilaginous covering, and probably in some instances an osseous cap or epiplysis.

Dr. Hayden visited the locality of Mr. Lucas' excavations, and informs me that the formation from which the *Camarasaurus* was obtained, is the Dakota. Prof. Marsh has attempted to identify what is, according to Prof. Mudge, the same horizon, one hundred miles north of Canyon City, with the Wealden of England. Specimens from the northern locality which I have examined render it certain that the horizon is that of Mr. Lucas' excavations. Of this I may say that there is no paleontological evidence of its identity with the Wealden. The resemblance of the vertebrate fossils to those of the English Oolite is much greater, but not sufficient as yet for identification.

The discovery of *Vertebrata* in the strata of the Dakota epoch is an important addition to the geology and paleontology of North America. The numerous geologists who have explored its outcrops have failed hitherto to observe remains of this class of animals. Credit is due to Superintendent O. W. Lucas for this discovery, and also in an especial manner for the skill and care he has exercised in taking out and shipping the ponderous specimens.

CAMARASAURUS Cope.

Palæontological Bulletin No. 25, p. 5; (published August 23, 1877).

The characters of this genus are derived from nearly all portions of the skeleton excepting the skull and ungues. The bones are generally in good preservation.

The vertebræ of the cervical, dorsal and lumbar region are all opisthocoelous or reversed ball and socket. The centra of the cervicals are very elongate, but those which follow them diminish rapidly in length, until in the lumbar region they have but a small anteroposterior diameter. The anterior caudal vertebræ are also very short and wide; but the length of the centra gradually increases, so that the distal ones are quite elongate. The caudal centra are all moderately amphicoelous.

The centra of the cervicals and dorsals are hollow, and the interior

chambers communicate with the cavity of the body by a large foramen on each side, which is below the base of the diapophysis. In the cervical vertebra it is very elongate, and extends between the bases of the parapophysis and diapophysis. In the dorsal centra there are but two chambers, which are separated by a longitudinal median septum.

The neural arches are coössified with the centrum throughout the column. They are extraordinarily elevated, and their antero-posterior diameter is small. The zygapophyses are at its summit, and have extensive articulating surfaces. The anterior pair are divided by a deep median fissure, while the posterior are united, and support as a pendant from their inferior median line a *hyposphen*, a structure more fully described under the head of the genus *Amphicoelias*, where it is equally developed. When the vertebræ are in relation, the base of the hyposphen enters the fissure between the anterior zygapophyses, and maintains them in position. This structure is obsolete in the lumbar vertebræ.

The diapophyses rise from the neural arch to a considerable length upwards and outwards, in the anterior dorsals. They become shorter posteriorly, but in none of the vertebræ anterior to the sacrum do they issue from the centrum. In the caudal vertebræ they are short and robust, and issue from the superior part of the centrum, They do not continue far on the tail. Those of the dorsal vertebræ are light and concave below. They are supported by thin osseous buttresses, the most important of which are the two inferior ones. The anterior of these is much the most prominent, and bears the capitular articular facet for the rib. In no case is this surface seen on the centrum, but it descends somewhat in the posterior vertebræ, but not as low as the level of the neural canal.

The neural spines are rather short, and are set transversely to the axis of the animal. The superior portion is expanded transversely, and in an anterior dorsal vertebra, is widely emarginate above, so as to appear double. The neural spines of the caudal vertebræ are compressed and elevated, though thickened at the apex. The zygapophyses are situated low down, and are directed very obliquely. The chevron bones of the caudal vertebræ have short limbs which are not united at the base, and a long common median spine.

The sacrum is short and consists of only four vertebral centra, thoroughly coössified. The anterior articular extremity is convex; that of the posterior extremity slightly concave. Its transverse processes are, like those of the other vertebræ, much elevated, although they spring from the centra. The external face of their bases is not prominent, and the spaces between their projecting portions are deeply excavated. The centra are like those of the caudal vertebræ, composed of dense bone. The extremities of the adjacent transverse processes are united, thus enclosing large foramina.

The scapula is relatively of large size. It is rather elongate, and the superior extremity is expanded. There is a very large mesoscapular process, which is wanting in *Cetiosaurus*, according to Phillip's figures. It appears to resemble the scapula in *Dystrophæus*.* The two proximal faces,

*See Report of Lt. Wheeler, Vol. IV, pl. LXXXIII, p. 31.

the glenoid and the coracoid, are well distinguished, and their surfaces are like the corresponding faces of other bones, pitted coarsely.

The coracoid bone is of proportionately small size. It is of an irregularly quadrate form, with the proximal extremity the shortest. The articular face is large, and is presented obliquely away from the long axis of the plate. There are no emarginations nor intermediate processes, and the perforating foramen is well removed from the border.

Pelvic bones of two forms are present. Neither of them resembles pelvic bones of *Dinosauria*, and are least of all similar to the forms of ilium which are known in that order. One of them is a robust L-shaped bone, one limb of which is expanded into a wide fan-shaped plate; and the other is stouter and of sub-equal width, terminating in a stout sub-triangular articular extremity. The face of this limb of the bone which looks away from the fan-shaped plate is concave throughout its entire length, forming a large part of the acetabulum. Both edges of this cavity are free and rounded. The absence of articular faces above the acetabulum renders the identification of the bone with either pubis or ischium difficult. The second pelvic bone is larger than the first, and unlike it, is in one plane. Its form is that of a low triangle with a long base, at each extremity of which the angles are truncated. The "basal" border is gently concave in the long direction and thick and convex in the cross-section, The two "sides" of the triangle are rather thin margins, but one of them is thicker than the other. One extremity of the bone is more robust than the other, and is divided into two planes. The one is transverse and sub-triangular, and applies to the extremity of the stout or acetabulum limb of the other pelvic bone. The other is smaller, is oblique and concave, and when the two bones are placed in relation, forms a continuation of the acetabular surface already described. Within this and the proximal portion is a large foramen which resembles the pectineal perforation of the pubis.

The femur is long and without prominent third trochanter, this process being represented by a low ridge. The condyles have an extensive posterior sweep, and are separated by a shallow trochlear groove in front. A tibia which was found with the other bones, is much shorter than the former, and has a much expanded head. It is very robust, especially at the distal extremity. The astragalus was evidently distinct from it. A metapodial bone is very robust. Its extremities are much expanded, and the shaft contracted, and it is furnished with a prominent median keel on one half of its posterior aspect.

Several genera have been described, which possess some of the features presented by those to which the present animal belongs. The following are characterized by the presence of the lateral sinuses of the vertebral centra: *Megadactylus* Hitch., *Cetiosaurus* Owen, *Ornithopsis* Seeley, *Bothrospondylus* Ow., and *Pneumatarthrus* Cope. The first of these may be dismissed with the remark that its caudal vertebræ possess the sinuses as well as the dorsals, which we have seen is not the case with the Colorado animal. The centra of *Cetiosaurus* according to Owen, and those of

Pneumatarthrus, do not exhibit the cavernous structure above described, but are uniformly spongy interiorly. *Ornithopsis* of Seeley, which Owen refers to his subsequently described *Bothrospondylus*, possesses a cavernous cellular structure, which I have not found in the reptile from Canyon City, Colorado, but which occurs in the huge saurian discovered by Prof. Lakes, near Golden, Colorado, in the same stratigraphical horizon. Another name (*Chondrosteosaurus*) has been introduced by Prof. Owen, but he gives no characters, nor points out how it differs from *Ornithopsis*, which it resembles in its cellular structure.

A short time prior to my publication of the description of the genus *Camarasaurus*, Prof. O. C. Marsh of New Haven issued a description of a portion of a sacrum of a saurian found in the Dakota beds near Morrison, Colorado, a point one hundred miles north of Canyon City. To the animal to which the sacrum belonged, Professor Marsh gave the name of *Titanosaurus montanus*. As the name of the genus was not accompanied by any generic diagnosis or specific reference to its characters, it has no claim to adoption according to the rules of nomenclature, nor is the genus distinguished from some of those above enumerated. Especially is there nothing to indicate that it differs from *Ornithopsis* or *Bothrospondylus*. The name given has also been already employed by Dr. Lydekker of the Geological Survey of India.

CAMARASAURUS SUPREMUS Cope.

Paleontological Bulletin, No. 25, p. 7; Aug. 1877.

The bones of this species so far discovered by Mr. Lucas are:—a cervical and twenty dorsal and lumbar vertebræ, with twenty caudals. Both scapulæ and coracoids were recovered, with one-half of the sacrum, and two pairs of pelvic bones. Of the hind limb I have the femur, with a tibia less certainly belonging to the same animal, although found among the other bones. There is one metapodial. There are many other bones which I have not yet reconstructed or determined.

The dimensions of this animal may be inferred from the fact that the cervical vertebra is twenty inches in length and twelve in transverse diameter; and that one of the dorsals measures three and a half feet in the spread of its diapophyses, two and a half feet in elevation and the centrum thirteen inches in transverse diameter. Another dorsal is two feet ten inches in elevation. The scapula is five and a half feet in length and the femur six feet.

The centra of these vertebræ bear a ball and socket articulation of the opisthocoelian type, the cups and balls being well pronounced; just beneath the diapophysis is situated a huge foramen. A broken centrum from which Mr. Lucas removed the matrix, shows that this foramen communicates with a huge internal sinus, which occupies almost the entire half of the body of the vertebra. Those of opposite sides are separated by a septum which is thin medially. Thus the centra of the dorsals are hollow. The neural arches are remarkable for their great elevation, and the great expanse of the zygapohpyses. They are more remarkable for the

form of the neural spines, which are transverse to the long axis of the centrum. That of one of the vertebræ is strongly emarginate so as to be bifurcate. The widely extended diaphophyses support the rib articulations, and there are no capitular articular facets on the centra.

The cervical vertebra is depressed, the anterior or convex extremity of the centrum the most so. It is remarkable for its elongate form, exceeding the proportions found in known *Dinosauria* and *Crocodilia*, and resembling that seen in some fluviatile tortoises. Near the anterior extremity a short, robust parapophysis has its origin, from which it extends outwards and downwards, and soon terminates in a truncate extremity which presents downwards. A deep fossa occupies its upper base, and above this a deep linear foramen extends throughout the greater part of the length of the centrum. If this vertebra possesses a diapophysis it is rudimental.

The caudal vertebræ are amphicœlian, but not deeply so. They are subquadrate in section, and not so short as the corresponding ones of *Hadrosaurus*. The most anterior one of the series has short, robust diapophyses, and is more concave anteriorly than posteriorly. The other caudals are more equally biconcave, but the cavity is very shallow on the most distal of them. The centrum is relatively more elongate and compressed than those of the others. None of them display the lateral pneumatic fossa which exists in the dorsals, and where broken so as to permit a view of the internal structure, the latter appears to consist of rather finely spongy tissue. The chevron facets are not very well defined, and the neural spines are of usual forms, and on two anterior vertebræ elongate.

Many peculiarities are exhibited by the vertebræ of this species, which are not described in saurians known up to the present time. Many of these would have been lost in less careful hands than those of Mr. Lucas, and science is much indebted to him for the preservation of many walls and buttresses of light proportions. In general the external walls of the centra are thin, and the processes are composed of laminæ united by narrow margins. The vertebræ are lighter in proportion to their bulk than in any air-breathing vertebrate.

The anterior extremity of the centrum of the cervical vertebra is prominently convex, and much depressed. The posterior and concave extremity is wider, and of rather greater vertical diameter. The base of the neural arch only occupies half of the length of the centrum, an equal extent of the superior surface extending freely beyond it at its anterior and posterior extremities.

The linear lateral foramen commences a little behind the anterior base of the neural arch, and descending somewhat in its direction, terminates beneath the posterior extremity of the base of the neural arch. The base of the latter overhangs the foramen and the base of the transverse process. The interior surface of the centrum is concave, the concavity being bounded in front by the inferior convex thickening of the extremity. Behind the middle the surface becomes plane, and is, near the posterior extremity, bounded on each side by a short angular ridge.

Measurements.	M.
Length of centrum between anterior convexity and posterior lip	.565
Depth of posterior cup	.090
Diameter of cup vertical	.310
Diameter of cup transverse	.160
Length of parapophysis	.095
Width of neural canal	.063

The dorsal vertebra which I suppose the anterior one of those received, is characterized by the lack of the median portion of the neural spine, and the extension outwards of the median lateral processes described above. The diapophyses are much longer, and the zygapophyses more extended transversely. The centrum is constricted at the middle, and especially just behind the convex articular extremity, whose circumference forms a prominent rim. The edges of the lip are flared outwards, forming a deep basin, much wider than deep. The fossæ described in other vertebræ are present in this one, but differs in proportions, owing to the greater size and expanse of the superior parts of the neural arch. The fossa posterior to the base of the diapophysis is nearly plane, while that at the anterior base is deeply excavated, is narrower, and extends so far along the inferior side of the process as to give it a semi-circular section near the middle. Distally the diapophysis has a trialate section, owing to its three longitudinal ridges, and the articular extremity is large and antero-posterior in direction. The process differs from that of the vertebra next described, in the possession of a facet near the middle of its anterior inferior bounding ridge, which is probably costal, as in the vertebra of *Crocodilia*. The lateral foramen of the centrum is subround. The general surface is smooth.

Measurements.	M.
Total elevation of vertebra	.770
" transverse extent of diapophyses	1.010
Diameter of centrum longitudinal	.300
Diameter of centrum vertical of cup	.250
Diameter of centrum transverse of cup	.340
Diameter of centrum " at middle	.205
Elevation of zygapophysis above centrum	.310
Diameter of zygapophysis transverse	.170
Diameter of zygapophysis antero-posterior	.090
Width of neural canal	.085
Transverse extent of neural spine	.440
Length of diapophysis from posterior zygapophysis	320
Antero-posterior width of end of diapophysis	.135

A dorsal vertebra from a more posterior position, is characterized by its undivided transverse neural spine. The entire neural arch is of enormous elevation, but as the zygapophyses are above its middle, the neural spine is not as long relatively as in various other genera or as in the

caudals of this one. The sides of the centrum are strongly concave, and the borders of the cup flaring. The neural arch is everywhere excavated, so as to reduce the bulk, and produce lightness so far as consistent with strength. The diapophysis rises from a point above the neural canal. It sends a narrow ridge down to the sides of the latter, on each side of which its shaft and base are deeply excavated. The posterior of these fossæ is overlooked by the wide zygapophysis; and the roof of the anterior one supports the anterior zygapophysis. The former are separated by another and vertical septum, which bifurcates below, forming two prominent borders of the neural canal. At each side of the base of the neural canal there are two trilateral fossæ, of which the anterior is much the larger and extends higher upon the lateral edge of the spine, They are separated by a lamina. The diapophysis is not very long and is subtriangular in section near the extremity. The neural spine is thickened at the extremity as though for the attachment of a huge ligament, At the summit of its posterior basal fossa, at the middle of its height, is an outwardly curved process with a smooth extero-superior face.

Measurements.	M.
Length of centrum	.275
Total elevation of vertebra	.830
Elevation to posterior zygapophyses	.550
" of superior edge of diapophysis above centrum	.350
" " neural spine above posterior zygapophyses	.295
Length of diapophysis behind	.215
Depth of extremity of do. (restored)	.075
Transverse extent of summit of neural spine	.215
" " neural spine at middle	.330

In a dorsal vertebra from a more posterior position, the centrum is larger. The capitular costal articulation occupies a lower position, its inferior edge being in line with summit of the neural canal. The lamina which supports it is separated from the anterior lamina which is at the base of the diapophysis, by a deep cavernous sinus. The posterior zygapophyses send upwards to the broad neural spine a median buttress each, which enclose a fossa with the marginal buttress of the same. The hyposphen is represented by a vertical lamina only.

	M.
Total elevation of vertebra	.900
Elevation of neural spine	.300
" " " distally	.280
Diameter posterior articular face of centrum	.360

A lumbar vertebra displays a greater expanse of the posterior articular extremity, which is expanded like a dish. The neural arch and transverse processes have a small fore and aft diameter, and the lateral caverns at the base of the diapophysis are obsolete. The pneumatic foramina are slightly higher than long. Posterior zygopophyses are wanting.

		M.
Diameter of centrum	vertical	.380
	transverse	.420
	antero-posterior	.170
Expanse of diapophyses		.590
Vertical extent of base of diapophysis to capitular surface		.200

A proximal caudal gives the following

Measurements.		M.
Total elevation		.560
Diameter of centrum	antero-posterior	.170
	transverse	.245
	vertical	.245
Antero-posterior diameter of neural spine		.075
Elevation of the neural canal		.040
Diameter of median caudal	fore and aft	.180
	vertical	.200
	transverse	.192
Diameter of posterior caudal	fore and aft	.155
	vertical	.175
	transverse	.145

A distal caudal of the elongate type has the following dimensions :

		M.
Diameter of centrum	antero-posterior	.155
	transverse	.125
	vertical	.100

The long diameter of the basis of the transverse processes of the large anterior caudal vertebræ is directed obliquely upwards and forwards. The anterior faces of some of these centra are flat.

The length of the sacrum is M. 0.900 ; elevation of first sacral rest, 0.500.

The head of the femur is subround. One side of the shaft is damaged, so that the form of its section cannot be ascertained. The side of the inner condyle is quite flat, and without epicondylar rugosity.

Measurement of femur.	M.
Length	1.820
Antero-posterior diameter of head	.310
" " " internal condyle	.450

The anterior and posterior edges of the scapula are thin. The posterior is slightly concave, with a slight projecting irregularity near the middle, and is then turned decidedly backwards, bounding the glenoid extremity. The glenoid face is concave, and longer than the coracoid suture. The anterior border is more strongly concave, the distal extremity being more expanded forwards. The sides of this extremity are slightly rugose with coarse grooves. The articular facets are pitted. A low keel extends along the external side of the mesoscapula.

Measurements.	M.
Total length	1.517
Width distally	.680
" at middle	.325
" at mesoscapula	.810
Length of glenoid face	.400

The articular extremity of the coracoid is recurved and very robust. The borders of the bone are thick and roughened.

Measurements of Coracoid.		M.
Diameter	extero-internal	.690
	antero-posterior	.560
	vertical proximally	.

Measurements of Metapodial.		M.
Diameter proximally	transverse	.160
	antero-posterior	.095
Diameter medially	transverse	.075
	antero-posterior	.120
Diameter distally	transverse	.210
	antero-posterior	.105
Length		.270

That this species was capable of and accustomed to progression on land is certain from the characters of the bones of the limbs and their supports above described. The extraordinary provision for lightening the weight of a portion of the skeleton has more than one significance. It must be borne in mind that the caudal vertebræ retain the solid character seen in those genera which stood habitually on their hind limbs. That the present species was herbivorous is suggested simply by its huge dimensions, and the natural difficulty of supplying it with animal food.

AMPHICŒLIAS Cope.

Paleontological Bulletin No. 27, p. 2 (Published December 10, 1877).

The genus to which the above name is now given, is allied to *Camarasaurus*, of which, and the gigantic species *C. supremus*, I have given an account in my Paleontological Bulletin, No. 25. Both genera differ from their nearest ally *Ornithopsis* Seeley, in the excavation of the vertebral centra, so as to include large chambers separated by a septum, which communicate with the external medium by a lateral foramen. In the *Ornithopsis* it is stated that the vertebral centra are occupied by a number of coarse cells. In the more remotely allied *Cetiosaurus*, Owen has observed that the tissue of the centra is coarsely spongy.

The vertebræ from all parts of the column of *Camarasaurus* are known, and those of the dorsal and lumbar regions present the extraordinary character, of which a trace is seen in *Cetiosaurus*, of neural spines expanded transversely to the axis of the column. Numerous vetebræ of *Amphicœlias* are known, and in the dorsals in which the neural spine is preserved,

the latter displays the usual form, that is, it is compressed in the direction of the axis of the column. The centra differ from those of *Camarasaurus* in the form of their articular extremities, resembling more nearly in this respect the genus *Tichosteus* Cope (Paleontological Bulletin, No. 26, p. 194). They are unequally amphicœlous, the posterior extremity being more concave, and with prominent margins; while the opposite one is less expanded and is but slightly concave. The neural arch is coössified to the centrum, and there is no capitular costal articulation on the latter.

The manner of the mutual articulation of the neural arches in this genus is peculiar, and is only paralleled in the genus *Camarasaurus*, so far as I can ascertain. The anterior zygapophyses are separated by a deep fissure, while the posterior zygapophyses are united on the middle line. From the latter from the point of junction, there descends a vertical plate which rapidly expands laterally, forming a wedge whose base looks downward. The supero-lateral faces are flat, and articulate with corresponding facets on the inferior side of the anterior zygapophyses, which look downward and inward, on each side of the fissure above described. When in relation, the anterior zygapophyses occupy a position between the posterior zygapophyses above, and the *hyposphen*, as I have termed the inferior reversed wedge, below. This arrangement accomplishes the purpose effected by the zygosphenal articulation, that is the strengthening of the articulation between the neural arches, but in a different way. The additional articulation is placed at the opposite extremity of the vertebra, and it is the anterior zygapophysis instead of the posterior one which is embraced. This structure entitles the genera which possess it to family rank, and as the two genera mentioned above belong to different families in consequence of the different types of vertebral centra, the one opisthocœlous, the other amphicœlous, they may be called *Camarasauridæ* and *Amphicœliidæ* respectively.

The pubis is a stout bone with one slightly concave, thicker border, and an opposite strongly convex, thinner margin. One extremity is truncate; the other presents one transversely truncate and one oblique face. The femur is elongate, and presents a strong postero-external ridge or third trochanter near the middle of the shaft. The head is not separated by a well marked neck, and the great trochanter does not project beyond it.

Thus while there is a striking resemblance to *Camarasaurus* in what may be regarded as adaptive characters, in some important essentials the two genera are very different.

Amphicœlias altus Cope.

Paleontological Bulletin, No. 27, p. 3.

The centrum of the dorsal vertebra of this reptile is contracted both laterally and inferiorly, so that the margins of the articular extremities flare outwards. The sides are flat, and the inferior surface but little convex in the transverse direction. The pneumatic foramen is situated at the bottom of a large lateral fossa which extends nearly the entire length of the superior

portion of the centrum. Its inferior border is sunken abruptly, while the superior gradually shallows on the external surface of the base of the neural arch. The foramen is longer than high, in contradistinction to that of the *Camarasaurus supremus*, where it is round or higher than long.

The neural arch is very much elevated to the zygapophyses. It is strengthened by a prominent rib, which extends from the posterior base upwards and forwards to the base of the anterior zygapophysis. The surface above and behind this is occupied by an extensive excavation whose superior border is the line connecting the zygapophyses. The anterior zygapophyses are separated medially by a deep notch which extends to the base of the neural spine. The articular surfaces incline towards each other. Just behind the anterior zygapophysis, a process extends outwards and forwards whose extremity is lost in my specimen. Its posterior face is excavated by the lateral fossa above described. This process is probably the diapophysis which supports the rib. The diapophysis springs from the line connecting the zygapophyses, and extends upwards and outwards. Its inferior surface is deeply excavated. Its anterior border sends a lamina upwards, which probably reached the side of the neural spine, but is broken off in my specimen.

The neural spine is thin, but its anterior and posterior borders are thickened and double, the lateral rib-like edges being separated by grooves which expand at the base. The posterior groove continues to a more elevated point than the posterior. Each side of the spine is divided into two shallow wide grooves by a median keel. The apex of the spine is much thickened transversely, its obtuse extremity having the fore and aft and transverse diameters equal.

The pubic bone resembles that of the *Camarasaurus supremus*, but is less robust in all its parts. It is also less extended in antero-posterior width near the proximal extremity.

The femur is remarkable for its slender form. It is a few inches longer than that of the *Camarasaurus supremus*, but is not so robust. The shaft is nearly round and somewhat contracted at the middle, where it is slightly convex backwards. It is slightly curved inwards at the great trochanter. Here the shaft is moderately grooved on the posterior face. This trochanter is only a prominent ledge below the head. The third trochanter is situated a little above the middle of the shaft; it is a prominent obtuse ridge directed backwards. The condyles are extended well posteriorly, and are separated by a deep popliteal groove, which originates on the inferior portion of the shaft. They are also separated anteriorly by a shallow open groove. The external condyle is rather more robust than the internal.

The length of the femur is six feet four inches; the elevation of the dorsal vertebra three feet three inches.

Measurements.		M.
Diameter of dorsal centrum	fore and aft.....	.245
	vertical	.270
	transverse.....	.265

Total elevation of vertebra		1.100
Length of neural spine		.600
Elevation of anterior zygapophyses		.500
Diameter of neural spine	antero-posterior	.160
	transverse (at middle)	.065
	" at summit	.140
Depth of centrum below pneumatic foramen		.120
Fore and aft diameter of pneumatic foramen		.080
Length of pubic bone		1.060
Thickness of stoutest extremity		.140
Length of femur		1.524
Transverse extent of proximal end		.420
" " " condyles		.320
Diameter of middle of shaft		.220
Distance from head to third trochanter		.665
Diameter of head (compressed)		.260

AMPHICŒLIAS LATUS Cope.

Paleontological Bulletin, No. 27, p. 4.

Of the wonderful fauna of the Dakota epoch of the Rocky Mountains the *Camarasaurus supremus* was preëminent in general proportions, the *Amphicœlias altus* was the tallest, and the saurian now to be described, was the most robust. It is represented in Mr. Lucas' collection by a right femur and four caudal vertebræ which are in good preservation. They reveal the existence of another saurian of huge dimensions, and of great mass in proportion to its height.

The caudal vertebræ are apparently from the anterior part of the series. They are all strongly bi-concave ; the anterior face more so than the posterior. They all possess diapophyses of depressed form, which take their origin below the base of the neural arch. The centra are short in antero-posterior diameter, and do not present lateral angles. They are composed of not very dense osseous tissue. The anterior zygapophyses are rather elongate, and their articular faces are directed steeply inwards. They are received by corresponding shallow excavations, one on each side of the posterior base of the neural spine. The neural spines are compressed and straight, and become very robust towards the apex.

The femur is extraordinarily robust. The great trochanter is low, but the shaft is widest where it expands outward. The third trochanter is a ridge, is above the middle, and is short and little prominent. It is on the inner edge of the posterior aspect of the shaft, and looks backwards and inwards. The shaft in its present state is compressed so as to reduce the antero-posterior diameter. It is not however crushed or cracked. The condyles have much greater transverse than antero-posterior extent. They are moderately produced backward, and are separated by a deep inter-condylar groove, while the anterior trochlear groove is wide and well marked. The inner condyle is narrowed posteriorly, while the external one is obtuse and robust.

The articular extremity is marked with irregular pits as in *Dystrophæus* and *Cetiosaurus*.

Measurements.		M.
Diameter of anterior caudal vertebra	fore and aft...	.150
	vertical.....	.200
	transverse.....	.260
Elevation to zygapophyses of the same.....		.250
Total elevation of the same.....		.480
Length of femur.....		1.400
Proximal diameter of femur	fore and aft.....	.165
	transverse	.410
Distal diameter of femur	fore and aft.....	.360
	transverse.....	.450
Diameter of middle of shaft of femur.....		.280

The caudal vertebræ of this species are much more deeply biconcave than those of the *Camarasaurus supremus;* they also differ in their relatively and absolutely greater breadth of centrum.

TICHOSTEUS Cope.

Paleontological Bulletin No. 26, p. 194 (Published November 21st, 1877).

Tichosteus lucasanus Cope.

Loc. cit.

SYMPHYROPHUS Cope.

Vertebral centra moderately elongate, slightly amphicœlous, and composed of uniformly and moderately dense osseous tissue. A narrow deep fossa in the floor of the neural canal. Neural arch coösified to centrum, with a lateral shallow fossa at its base. Neither costal articulation nor process on the centrum.

The coösification of the neural arch of this genus distinguishes it from the few amphicœlous crocodilian genera known from North America, and the fossa at its base is so shallow as to separate it from sauria of the *Pneumatarthrus* and *Ornithopsis* type.

Symphyrophus musculosus Cope.

A vertebra of this species is strongly concave laterally and distinctly so inferiorly. The anterior articular facets plane, the posterior slightly concave. The superficial layer of bone is dense and smooth, excepting near the edges of the articular surfaces, where it is rugose. The rugosity is arranged in a line within the articular faces, and consists of numerous small irregular pits and grooves which inosculate. Near the border the grooves assume a transverse direction. There is a nutritive foramen near the middle of each side of the centrum. There are traces of the neurapophysial suture, showing that the neural arch is distinct in young animals.

Measurements		M.
Diameter of centrum	antero-posterior.....	.032
	vertical.....	.027
	transverse.....	.031

The extremity of a humerus is expanded transversely and displays two unequal condyles, separated by a shallow groove. There are no epicondyles on the external face, but fossæ instead.

Measurements.	M.
Width of distal extremity of humerus	.086
Antero-posterior diameter of larger condyle of the same.	.045

Discovered by Superintendent Lucas near Canyon City, Colorado.

LAELAPS. Cope.

Transac. Amer. Philos. Soc. XIV, 1869, p. 100.

LAELAPS TRIHEDRODON. Cope.

Bulletin U. S. Geol Survey, Terrs. III, p. 805, August 15, 1877.

CAULODON. Cope.

Paleontological Bulletin, No. 26, p. 193, Nov. 21st, 1877.

CAULODON DIVERSIDENS. Cope.

Loc. cit.

CAULODON LEPTOGANUS. Cope.

A second species of the genus *Caulodon* is represented by a single tooth from a locality distant from that from which the *C. diversidens* was derived. Another tooth found with it probably belongs to the same species.

The best preserved tooth possesses the same general form as that of the *C. diversidens*, but the borders of the spoon-shaped crown are thinner and more acute. The convexity of the convex face of the crown does not commence at these edges, but is separated from them by an open shallow groove. There is a median longitudinal swelling at the middle of the length of the concave face. The striking peculiarity of this species is the very small amount of enamel which invests the crown. It is confined to the inner face, and exists there in a thin layer, not more than half as thick as in the *C. diversidens*, which thins out and disappears towards the edges of the crown. Another peculiarity is seen in its absolute smoothness. In *C. diversidens* the enamel, even when polished by use, shows remains of the grooves.

Measurements.		M.
Diameter of crown at base	fore and aft	.015
	transverse	.019
Diameter of crown at middle	fore and aft	.010
	transverse	.021

Found by Superintendent Lucas near Canyon City, Colorado.

COMPSEMYS. Leidy.

COMPSEMYS PLICATULUS Cope.

Paleontological Bulletin, No. 26, p. 195.

EXPLANATIONS OF THE FIGURES will be found at the end of this volume.

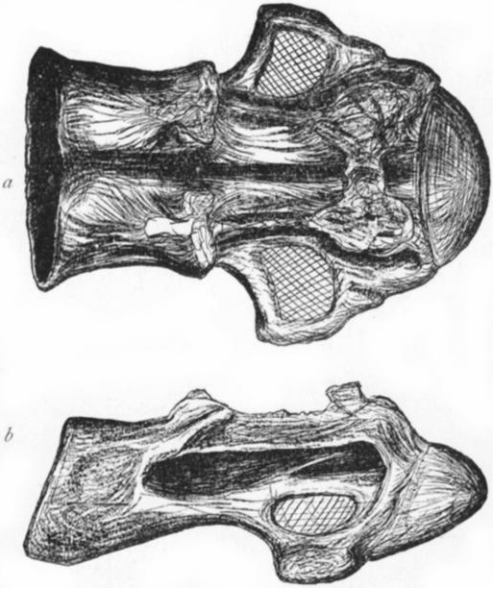


Fig. 1—Cervical vertebra of *Camarasaurus supremus*. *a* from above; *b* from right side. The neural arch is mostly wanting. These figures, like all the others in this paper, are one-tenth natural size.

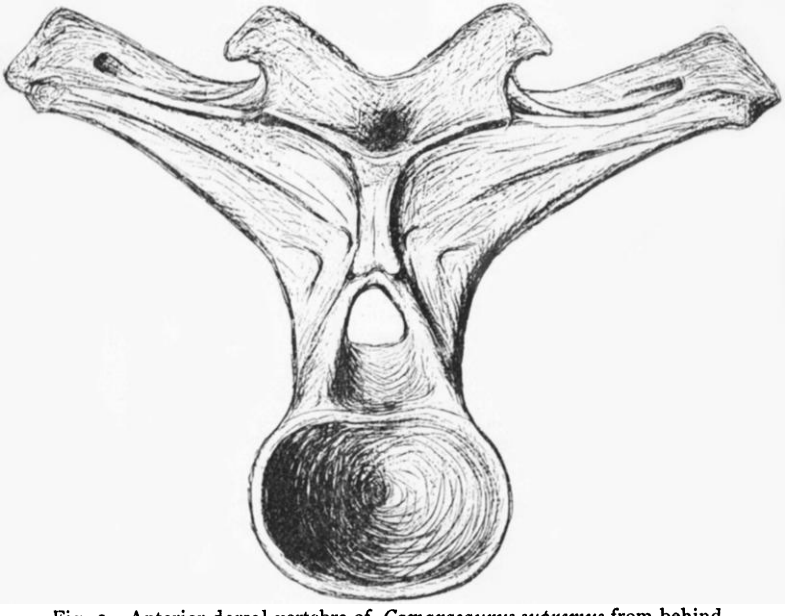


Fig. 2—Anterior dorsal vertebra of *Camarasaurus supremus* from behind.

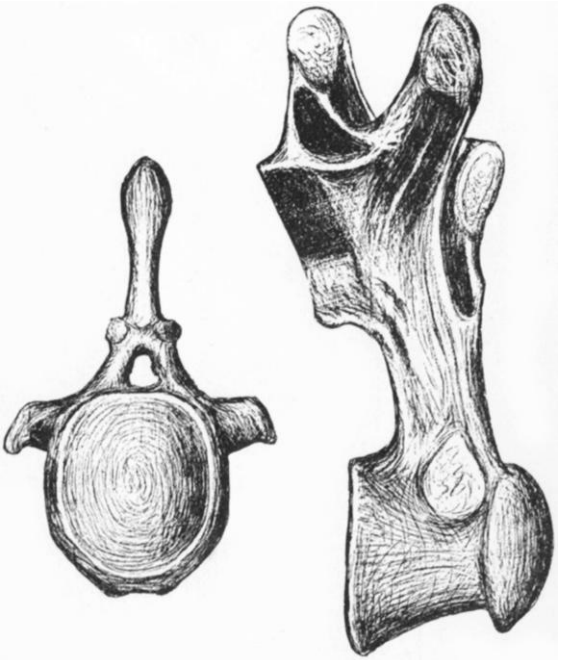


Fig. 4. Fig. 3.

Fig. 3—Dorsal vertebra represented in Fig. 1, the right sight side. Fig. 4—A caudal vertebra viewed from behind.

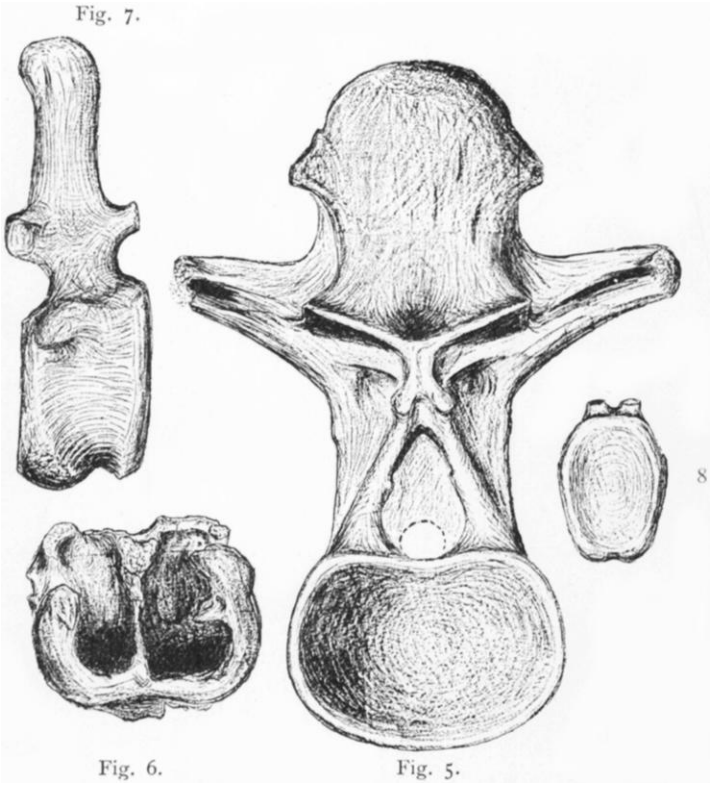


Fig. 5—A median dorsal vertebra seen from behind, showing the hyposphen. Fig. 6—Centrum of a dorsal vertebra without anterior wall. Fig. 7—Caudal vertebra shown in fig. 4, from the right side. Fig. 8—A more posterior caudal, end view of the centrum.

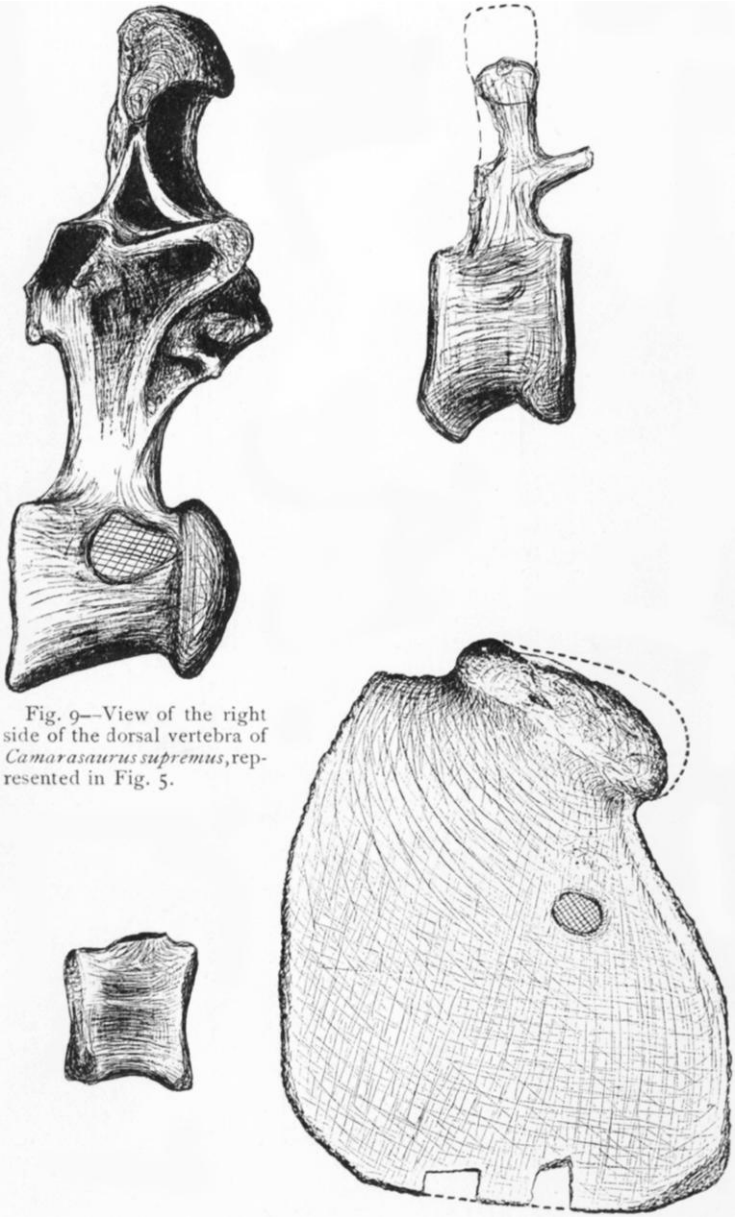


Fig. 9—View of the right side of the dorsal vertebra of *Camarasaurus supremus*, represented in Fig. 5.

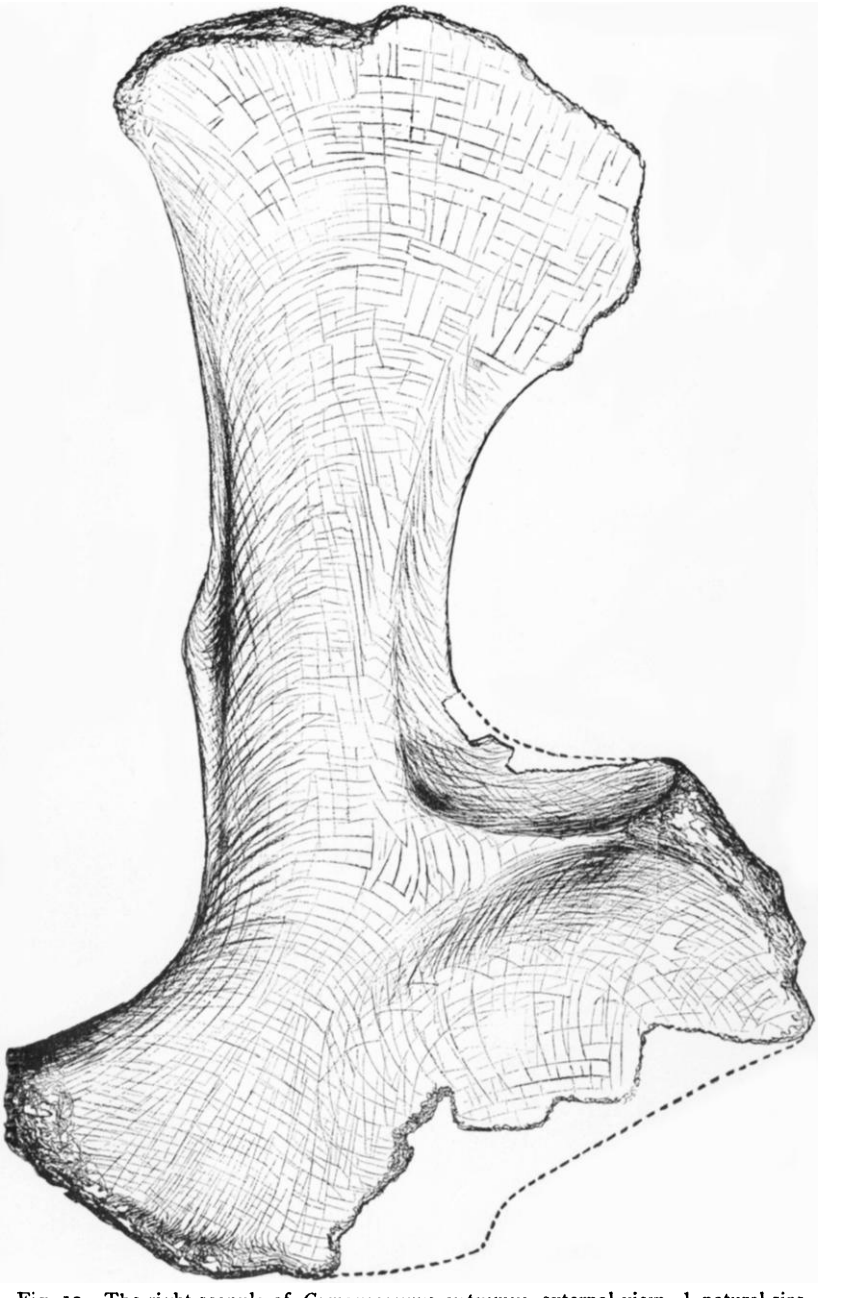
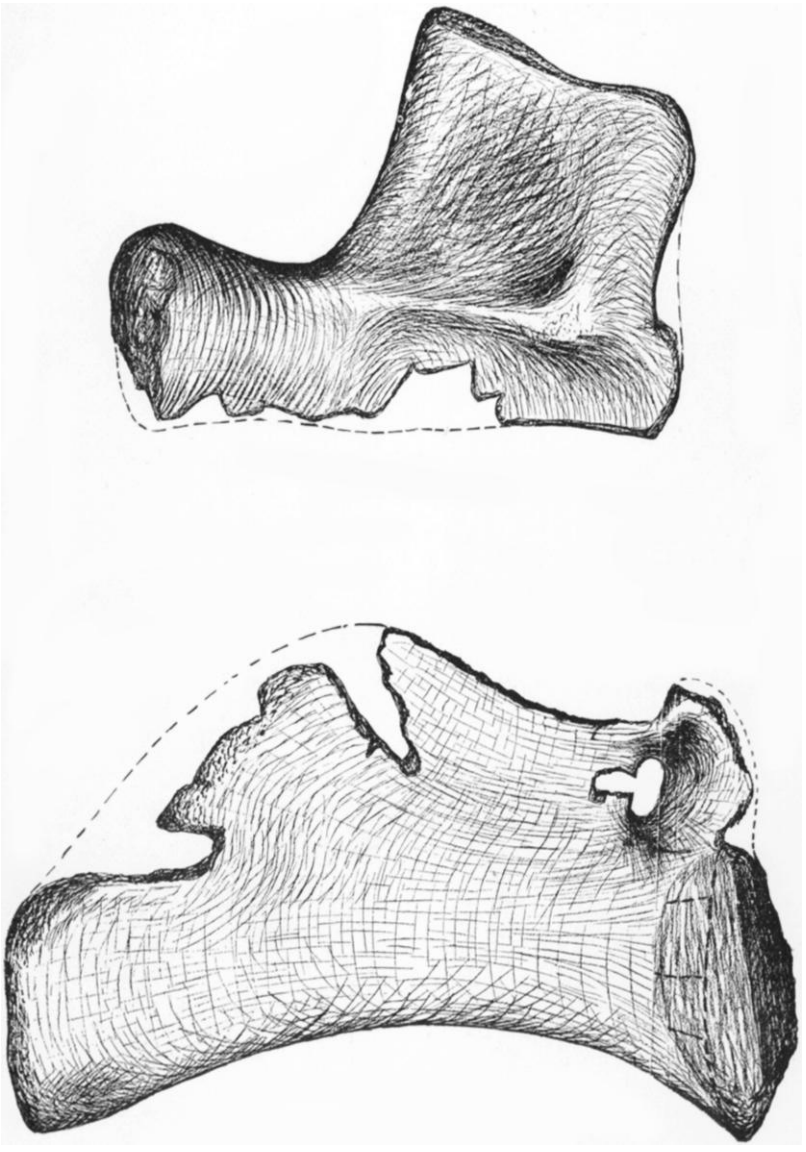


Fig. 10—The right scapula of *Camarasaurus supremus*, external view, $\frac{1}{10}$ natural size.



Figs. 11, 12—Pelvic bones of *Camarasaurus supremus*.

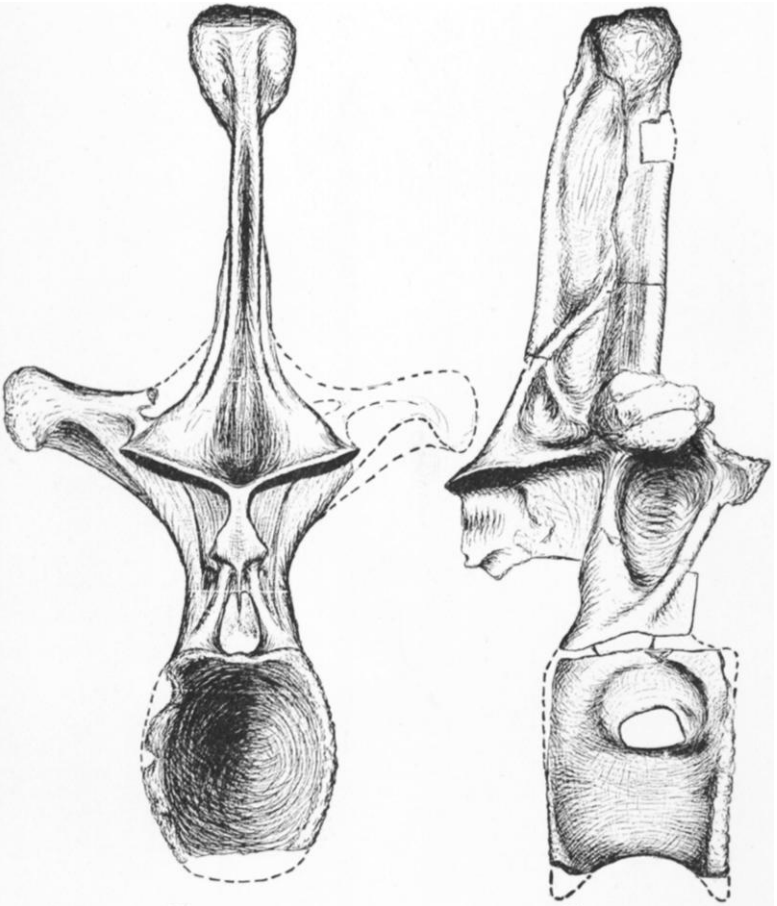
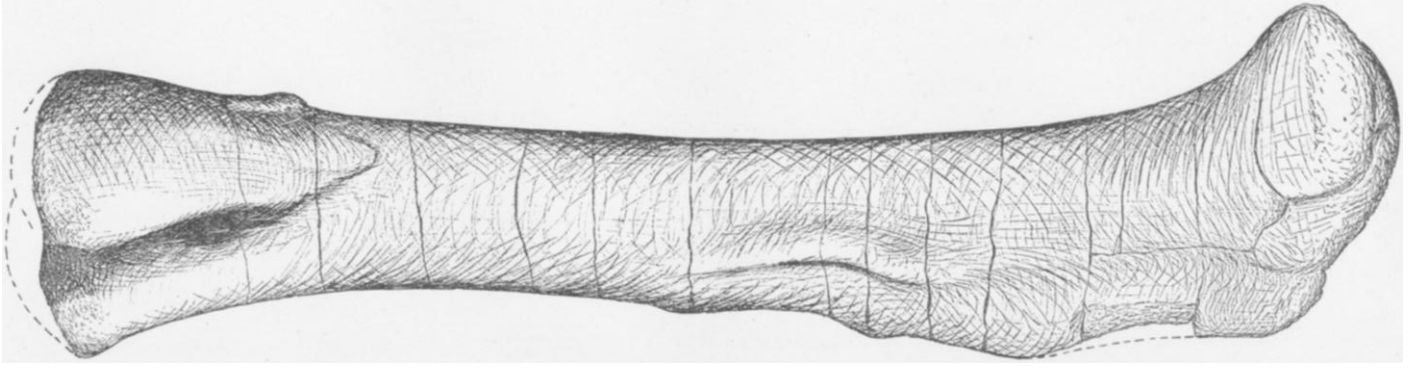


Fig. 13. Fig. 14.

Fig. 13—Dorsal vertebra of *Amphicœlias altus* seen from behind, exhibiting the hyposphen.

Fig. 14—The vertebra represented in Fig. 13 seen from the right side, displaying the excavations of the neural arch and spine, and the pneumatic foramen of the centrum.

Fig. 15—Femur of *Amphicœlias altus*, seen from the inner posterior direction.



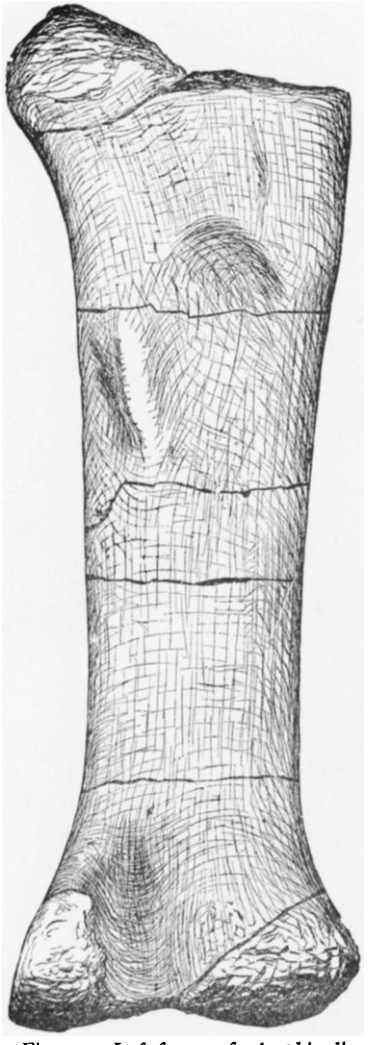


Fig. 17—Left femur of *Amphicœlias latus*, from behind.

Fig. 16—A caudal vertebra of *Amphicœlias latus*; *a* from before, *b* from the left side.